Original Article

Nepal Journal of Neuroscience 10:7-13, 2013

Endoscopic Third Ventriculostomy in the Treatment of Hydrocephalus: Review of 24 cases

Mohan R Sharma, MS
Neurosurgery Division
Department of Surgery
TU Teaching Hospital
Kathmandu, Nepal

Sushil K Shilpakar, MS
Neurosurgery Division
Department of Surgery
TU Teaching Hospital
Kathmandu, Nepal

Gopal Sedain, MS, MCh
Neurosurgery Division
Department of Surgery
TU Teaching Hospital
Kathmandu, Nepal

Address for correspondence:
Mohan R Sharma, MS
Neurosurgery Division
Department of Surgery
TU Teaching Hospital
Kathmandu, Nepal
Email: mohanrajsharma@gmail.com

Received, May 1, 2013
Accepted, June 10, 2013

Endoscopic third ventriculostomy (ETV) is considered as a treatment of choice for obstructive hydrocephalus (HCP) and a viable alternative treatment for HCP due to a variety of other causes. The objective of this study was to describe the clinical, radiological, and operative characteristics of patients who underwent ETV at our center, and analyze their outcome at three months.

Twenty four patients who underwent ETV over a period of three years, and who were followed up for a minimum of three months were selected for analysis. Thirteen were males and 11 females. Thirteen were infants; their average age at the time of operation was 6 months. All patients presented with signs of increased intracranial pressure (ICP). The mean follow-up period was 24 months (range 3-39 months). Hydrocephalus due to congenital aqueductal stenosis was the commonest indication for surgery (70.8%). Twenty one patients underwent ETV as a first surgical procedure for HCP. None of the patient had any anesthetic or procedure related complications. Eighteen patients had good outcome at three months. Four patients had complications related to ETV and two of them required conversion to shunt procedures. There were two deaths.

ETV is an effective method of treatment for patients with obstructive HCP. All patients with initially successful ETV should receive careful follow-up care on a regular basis to detect failures and complications. Although the rate of morbidity is relatively high even in experienced hands, most of the complications are minor in contrast to ventriculoperitoneal shunt placement. In this series, factors indicating potential poor ETV outcome are young age and associated comorbid conditions.

Key Words: Complications endoscopic third ventriculostomy, hydrocephalus, outcome

Hydrocephalus (HCP) is one of the commonly encountered neurosurgical conditions managed by neurosurgeons all over the world. A very many operative methods to treat this condition have been described since the middle of 19th century which yielded, however, unsatisfactory results in most instances. Results improved since the introduction of effective valve systems in shunts in 1950s. Despite improved results, the treatment of hydrocephalus still remains problematic.

Though the predominant mode of therapy for patients with HCP is shunt surgery (most commonly

Figure 1: Intraoperative photograph showing the introduction of trocar and sheath into the lateral ventricle through right frontal burr-hole.

ventriculoperitoneal shunt (VPS)), due to a number of unavoidable complications inherent to the insertion of a shunt, alternative approaches were thought and put into practice. One of these is the endoscopic third ventriculostomy (ETV), where an opening is made in the floor of the third ventricle so that CSF passes from the third ventricle to the prepontine cistern bypassing the obstructed cerebral aqueduct or fourth ventricle. Although ETV was introduced by Dandy and Mixter in early 1920s, it went into oblivion due to the high failure rate and high morbidity and mortality due to the technical limitations of the endoscope existing then.[10,14] Development of the valve system combined with the availability of new bioavailable materials in 1950s allowed for the comparatively safe and reliable diversion of CSF.[1] There was, and still is, a high rate of complications associated with even the newest and expensive versions of shunt materials (literally hundreds of options for valves, proximal and distal catheters, antisiphon devices to prevent over drainage, and, more recently, programmable valves for fine-tuning CSF flow rates.). In this background ETV was resurrected in 1980s as the limitations of shunts for chronic hydrocephalus became more obvious. In the 1990s, with better endoscopes and imaging capabilities, ETV gained wider acceptance for the treatment of HCP especially in patients with acquired or late-onset occlusive hydrocephalus. The main advantage of ETV over shunt placement is avoidance of complications related to shunt malfunction and low infection rate inherent to the placement of a foreign object.[10]

The most common and classic indication for performing ETV is obstructive HCP caused by congenital or acquired aqueductal stenosis (AS) and tectal tumors. Though traditionally communicating HCP has been a contraindication for ETV, there is some recent evidence to suggest that this procedure has some benefit.[3] ETV is not without complications. Intraoperative neural injury (thalamic, hypothalamic, forniceal and midbrain injuries), basilar artery injury, intraventicular/subduaral hemorrhage are some of the documented complications of ETV.[2] One important and dreadfull complication of this procedure is the sudden death syndrome.[6]

Till today ETV and shunts are both utilized in the treatment of HCP. A recent metanalysis comparing the effectiveness of these two techniques showed a relatively high failure rate associated with both techniques.[16] Though there is some evidence that ETV may confer long-term survival advantage over shunts in the treatment of non-communicating HCP, particularly in children and in patients with certain aetiologies such as AS, at present there is insufficient proof to unequivocally recommend one mode of treatment above the other.[16] The aim of this study was to retrospectively analyze the demographic characteristics, indications, peri/intraoperative difficulties, failures and complications of 24 consecutive ETV procedures performed at our center in last three years.

Materials and Methods

Twenty eight patients diagnosed with HCP, based on clinical findings of increased intracranial pressure and computerized tomography (CT) and or magnetic resonance imaging (MRI) scans of the head qualified to be treated by ETV at our center between February 2010 to February 2013. In one patient ETV could not be performed due to obscure third ventricular anatomy during operation. Three patients were lost to follow up. Remaining 24 patients constitute the basis of this study. Demographic, clinical, radiological and operative and follow up data of this patient population were reviewed from the hospital charts and computerized data bank of the Neurosurgery Unit of our hospital. Twenty two patients were followed up for a minimum of six months and two patients three months.

Management Protocol

Every patient with suspected HCP was evaluated by the neurosurgical team. Detailed neurological examination was performed noting specifically the size of the head in infants and level of consciousness based on Glasgow Coma Scale (GCS), and presence or absence of any neurological deficit in all patients. All patients underwent either MRI or CT scans of the head. The degree and type (communicative versus obstructive) of HCP were noted. Associated findings, such as presence of tumor or past evidence of infection, were also documented. All patients with obstructive HCP were routinely offered ETV unless contraindicated by a very small or nonvisible prepontine cisterns as seen on MRI. ETV was performed in a standard fashion with a burrhole 2-3 cm lateral to the midline and one cm anterior to the coronal suture. A trocar with sheath was passed into the lateral ventricle **(Figure 1)**. Once

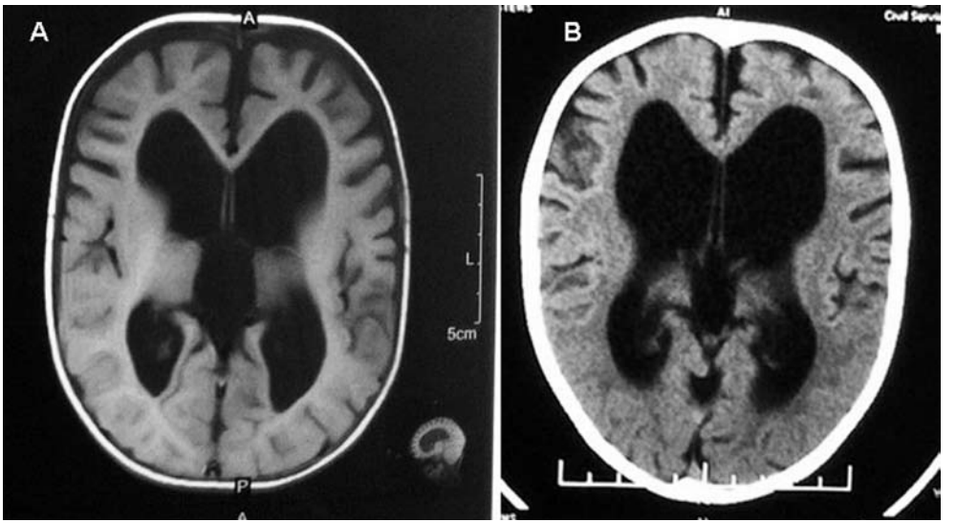

Figure 2 A: Pre-operative brain scan showing dilatation of lateral and third ventricles. B: Post-operative brain scan 6 weeks after ETV. The size of the third ventricle is reduced more compared to that of the lateral ventricles after the procedure.

the entry into the ventricle was confirmed the trocar was withdrawn and a rigid or flexible endoscope was passed through the frontal lobe into the lateral ventricle, then through the Foramen of Monro to the floor of the third ventricle. The floor of the third ventricle was punctured with a bumpy wire in front of the mamillary bodies. The opening was enlarged using a number two Fogarty catheter. Endoscopic inspection of basilar and posterior cerebral artery was made. The procedure was considered complete when free flow of CSF was seen through the stoma. Bleeding, if any, was controlled by copious irrigation with lactated Ringer's solution and gentle pressure at the edge of the stoma. After the withdrawal of the scope, the cortical tract was plugged with Gelfoam and the dura matter was closed with 4:0 vicryl. No EVD was placed at the end of the procedure in this series of patients.

Patients were usually kept in the hospital for two to three days and then followed up in the outpatient department. Good outcome was ascertained by resolution of symptoms and decrease in the rate of enlargement of head in infants. The majority of patients also underwent either CT **(Figure 2)** or MRI evaluation to document the resolution of HCP. Outcomes at discharge and at three and six months were assessed.

Results

A total of 28 patients underwent ETV for obstructive HCP over three years period. Four patients were excluded from the study for the reason previously mentioned. Therefore, 24 patients who were followed up for a minimum of three months were selected for further analysis.

Demographics and Clinical Presentation

There were a total of 24 patients. Thirteen were 13 males and 11 females. **Table 1** summarizes the distribution of patients on the basis of age groups. The average age of the infants (no. 13) under at the time of operation was six months ranging from 10 days to one year. The oldest patient was 30 years old. All patients presented with signs of increased intracranial pressure (ICP). In infants this was manifested by rapidly growing head size and or delayed development. Headache, vomiting and decrease in the level of consciousness were noted in older children and adults. Some patients with space occupying lesions (patients with posterior fossa lesion) also presented with the site specific symptoms. The mean follow-up period was 24 months (range 3-39 months).

Imaging

All patients underwent CT scan of the head. Nineteen of 24 patients had an MRI in addition to CT scan. An MRI scan was encouraged in all cases to assess the floor of the third ventricle and propontine area in the midsagital images in order to decrease the intraoperative complications but six patients could not undergo MRI due to either urgency of the situation (rapidly decreasing level

Age groups	No. (%)
< 1 yr	13
1-14 yr	8
>14 yr	3

Table 1: Distribution of patients based on age groups.

of consciousness) or lack of financial resources. **Table 2** shows the preoperative diagnosis of patients based on imaging studies.

Diagnosis	No. (%)
Congenital aqueductal stenosis	17
Posterior fossa tumor with HCP	1
Pineal tumor with HCP	1
Tectal plate tumor with HCP	1
Post tubercular aqueductal stenosis	1
Lumbar myelomeningocele with HCP	1
Dandy walker malformation with HCP	1

Table 2: Distribution of patients based on etiology.

Operative procedure

Twenty one patients underwent ETV as a first surgical procedure for HCP. In none of the patient EVD was placed after the procedure. In one patient with posterior third ventricular tumor, biopsy of the lesion was performed in addition to performing standard ETV. Two patients had undergone VPS placement in the past and these patients had shunt malfunction. The shunt 'tubings' were removed at the time of performing ETV.

Outcome

The surgical outcome in our series was satisfactory. None of the patient had any anesthetic or procedure related complications. Sixteen patients had good outcome at six months and last two patients were progressing satisfactorily at three months postoperatively.

Four patients had complications related to ETV and two of them required conversion to shunt procedures.

1. Persistent leak from the burrhole site despite reinforcing the wound with additional stitches. This patient underwent VPS placement on day 10 of ETV.
2. Failure of resolution of symptoms supported by failure of regression of size of the ventricles on CT scan. This patient underwent VPS at six weeks post ETV.
3. This three-month old male infant had undergone repair of the occipital encephalocele along with ETV in one setting. Despite technically satisfactory ventriculostomy, HCP did not resolve and he underwent VPS on day 16 post ETV.
4. Bilateral subdural hematoma in one patient who was treated conservatively. This patient had to stay in the hospital for a longer duration for close obervation. However no additional procedures were required.

We had two deaths in our series

1. This 5- month old male child with premature birth at seven months with a birth weight of 1.25 Kg had presented with overt signs of increased ICP. Clinical evaluation and investigations revealed gross obstructive HCP associated with Chiari II malformation. The child developed pneumonia on day six postoperatively. Despite aggressive antibiotics treatment, the child died on post-operative day 12.
2. This 22-year old female had gross obstructive HCP associated with pineal tumor who had presented to us with decreased level of consciousness (GCS 8). The patient responded well after initial ETV when her GCS returned to 15/15 on second postoperative day. On day eight she became lethargic rapidly and a new CT scan showed a significant HCP. An external ventricular drainage was emergently placed. However, she continued to deteriorate and died on postoperative day nine.

Discussion

ETV is nowadays a promising alternative and initial treatment of choice for triventricular HCP. Many factors have contributed to the popularity of ETV, the most important being the absence of the use of the foreign body with all its limitations and complications. Moreover, it is considered more physiological for CSF circulation.[4] A high success rate, and low complication rate have permitted the continuous review and expansion of indications for ETV. However, there is still no consensus as to which patient will benefit from ETV despite there being a scoring systems to predict success.[4,22]

Classic indications for ETV include HCP due to congenital and acquired AS secondary to brainstem and tectal tumors, idiopathic stenosis of the foramina of Magendie and Luschka, and Dandy–Walker malformation, In addition, it is performed as part of the procedure in the following situations; HCP due to intraventricular hematoma in addition to aspiration of hematoma, cerebellar hematoma, pineal tumors, posterior fossa tumors, or quadrigeminal cistern cysts. This procedure has also been reported to yield some limited success in the treatment of postinfectious/posthemorrhagic and communicating

and normal-pressure HCP.[7,10,13,21] With the dramatic rise in indications for ETV, new neurosurgical complications and technical difficulties are also simultaneously reported.[2,5,16]

Demographic Characteristics

In our series, 13 (54.1%) patients were below the age of one year. There was almost equal sex distribution with slight male preponderance (male: female= 13:11). This is consistent with previously published studies. In a report by Drake in a series of 368 Canadian pediatric paitients, 57% were male.[5]

Etiology and Imaging

All patients underwent CT scan of the head. Nineteen of 24 patients had an MRI in addition to CT scan. As for etiology, the majority of patients had congenital AS (70.8%). In the review by Bouras, et al., in 2884 patients the AS was reported in 29.3% of patients.[2] In the paper by Drake,et al., AS comprised 34 % of cases.[5] In the report by Gangemi, et al, involving 140 patients from four Italian centers, the etiology of the hydrocephalus was AS in 62.8% of patients.[8] As >50% of our patients were below the age of one year, this probably explains the high incidence of AS.

Outcome

The accuracy of an ETV success rate depends on many factors and is mainly a function of the definition of "success." There is a great variation in the literature as to what constitutes the good outcome- a patient's freedom of symptoms or absence of further CSF procedures. As suggested by Drake and the Canadian Pediatric Neurosurgery Study Group,[5] we used a definition of successful outcome as an absence of further CSF diversion procedures.

In 24 out of 25 patients we were able to perform the procedure successfully (96% technical success). In a series by Warf, et al., in 979 patients, they aborted the procedure in 281 cases. The most common difficulties associated with the surgery are narrow space between mammillary bodies and dorsum sellae, high localization of basal artery bifurcation, and opaque floor of the third ventricle bulging to the sellae.[9]

The success of ETV ranges from 56-89 % in different series. [12,15,21] In our study, 19 patients (79.2%) had success at three months. This is consistent with published studies. In a series by Sacko, et al., there was 68.5% success rate at three months. In the series by Warf, et al., in a large series of 979 children, 55.6% of completed procedures were successful at six months.[21] In the study by Gangemi and colleagues 12.9% required a shunt because of ETV failure.[8] As 97% of failures occur within two months and 95% within a month of the initial procedure,[15,17] we included minimum of three months of follow up to detect any failures. Two patients (8.3%) in our series required subsequent VPS for failure of resolution of symptoms.

Two patients (8.3 %) who had shunt malfunction underwent successful ETV in our series. In the series by Drake, 22% of the patients had been previously shunted.[5] Similarly, in the series by Obrien and colleagues, in a retrospective analysis of 233 patients, 63 patients underwent an ETV for shunt malfunction.[15]

There has been a debate whether patient's age, cause of hydrocephalus, or both influence the outcome. In the report by Drake, based on data from multiple Canadian centers, age seems to be the primary determinant of outcome in ETV in pediatric patients. Failure rates are particularly high in neonates and young infants.[5] There is some controversy regarding the difference in outcome between developing and developed nations. However, in a study by Kulkarni, et al., the response to completed ETVs of children in Uganda was found to be no different than that of children in developed nations.[12]

Complications

The incidence of complications with ETV has been reported to be between 0 to 20%.[2,4,5,6,8,11,16,17] In our series four (16.6%) patients experienced ETV-related complications, and this is not an insignificant number. As patients less than six months of age have high failure rate compared to older patients (a 5-fold increased risk of ETV failure than older patients[17]) our slightly high complication rate is probably due to our younger patient population.

Morbidity

CSF leakage and subdural hematoma were noted in each patient (4.1%). Both these occurred in children less than one year of age which is consistent with published reports that infants represent a high-risk group for complications.[4,17] To reduce the incidence of CSF leakage, smallest possible dural opening, use of a small single-use endoscope, plugging the cortical tract at the end of the procedure with Gelfoam, and closure of the wound in a watertight fashion have been suggested.[20] In the postoperative period, the patient should be kept as upright as possible to reduce CSF pressure on the wound and to decrease the sagittal sinus pressure, encouraging the absorption of CSF across the villi into the sagittal sinus. We had no thalamic or other injury or intraventricular hemmorhage in our series.

Mortality

The 8.3% mortality rate in our series warrants clarification. Both patients had significant co-morbid

conditions. This child of one month had a history of prematurity, associated Chiari II malformation and gross hydrocephalus. He succumbed to severe pneumonia postoperatively. The second death was quite unfortunate. This 22-year old female had gross obstructive HCP associated with pineal tumor and had presented in a comatose stage. Despite a successful ETV initially, patient deteriorated later and emergency external ventrucular drainage also could not save her. We surmise that probably the stoma on the third ventricular floor got blocked with resultant acute HCP.

The reported mortality of ETV is lower than 1%.[2] Our small sample size and different patient population (presentation at an advanced stage) probably explain the high mortality in our series.

Limitation of the Study

This study is retrospective in nature with its inherent drawbacks. This is also a single institutional study and therefore may not be fully generalized. Our sample size was small. Therefore, potential introduction of errors due to small sample size cannot be ruled out.

Conclusions

Our series shows that ETV is an effective method of treatment for adult patients with obstructive HCP. All patients with initially successful ETV should receive careful follow-up care on a regular basis to detect failures and complications . Although the rate of morbidity is relatively high even in experienced hands, most of the complications are minor in contrast to VPS placement. In this series, factors indicating potential poor ETV outcome are young age and associated comorbid conditions.

References

1. Aschoff A, Kremer P, Hashemi B, Kunze S:The scientific history of hydrocephalus and its treatment. **Neurosurg Rev 22:** 67-93, 1999
2. Bouras T, Sgouros S: Complications of endoscopic third ventriculostomy. **J Neurosurg Pediatr 7:**643-649, 2011.
3. De Bonis P, Tamburrini G, Mangiola A, Pompucci A, Mattogno PP, Porso M, Anile C: Post-traumatic hydrocephalus is a contraindication for endoscopic third-ventriculostomy: isn't it? **Clin Neurol Neurosurg 115:**9-12, 2013
4. Di Rocco C, Frassanito P, Massimi L, Tamburrini G: Prediction of outcome of endoscopic third ventriculostomy. **World Neurosurg** S1878-8750:00316-1, 2013
5. Drake JM: Canadian Pediatric Neurosurgery Study Group: Endoscopic third ventriculostomy in pediatric patients: the Canadian experience. **Neurosurgery 60:**881–886, 2007
6. Drake J, Chumas P, Kestle J, et al. Late rapid deterioration endoscopic third ventriculostomy: additional cases and review of the literature. **J Neurosurg (2 Suppl Pediatrics) 105:**118-126, 2006
7. Figaji AA, Fieggen AG, Peter JC: Endoscopic third ventriculostomy in tuberculous meningitis. **Childs Nerv Syst 19:**217-225, 2003
8. Gangemi M, Mascari C, Maiuri F, Godano U, Donati P, Longatti PL: Long-term outcome of endoscopic third ventriculostomy in obstructive hydrocephalus. **Minim Invasive Neurosurg 50:**265-269, 2007
9. Grand W, Leonardo J: Endoscopic third ventriculostomy in adults: a technique for dealing with the neural (opaque) floor. **J Neurosurg 114:**446-453, 2011
10. Hailong F, Guangfu H, Haibin T, Hong P, Yong C, Weidong L, Dongdong Z: Endoscopic third ventriculostomy in the management of communicating hydrocephalus: a preliminary study. **J Neurosurg 109:**923-930, 2008
11. Hellwig D, Grotenhuis JA, Tirakotai W, et al: Endoscpic third ventriculostomy for onstructive hydrocephalus. **Neurosurg Rev 28:**1-34, 2005
12. Kulkarni AV, Warf BC, Drake JM, Mallucci CL, Sgouros S, Constantini S; Canadian Pediatric Neurosurgery Study Group: Surgery for hydrocephalus in sub-Saharan Africa versus developed nations: a risk-adjusted comparison of outcome. **Childs Nerv Syst 26:**1711-1717, 2010
13. Kumar A, Singh K, Sharma V: Surgery in hydrocephalus of tubercular origin: challenges and management. **Acta Neurochir (Wien) 155:**869-873, 2013
14. Mccullough DC: **History of the treatment of hydrocephalus**, in Scott MR (ed): Hydrocephalus. Baltimore: Williams & Wilkins, 1990, Vol 3, pp 1-10
15. O'Brien DF, Javadpour M, Collins DR, Spennato P, Mallucci CL: Endoscopic third ventriculostomy: an outcome analysis of primary cases and procedures performed after ventriculoperitoneal shunt malfunction. **J Neurosurg 103(5 Suppl):**393-400, 2005
16. Rasul FT, Marcus HJ, Toma AK, Thorne L, Watkins LD: Is endoscopic third ventriculostomy superior to shunts in patients with non-communicating

hydrocephalus? A systematic review and meta-analysis of the evidence. **Acta Neurochir (Wien) 155:**883-889, 2013

17. Sacko O, Boetto S, Lauwers-Cances V, Dupuy M, Roux FE: Endoscopic third ventriculostomy: outcome analysis in 368 procedures. **J Neurosurg Pediatr 5:**68-74, 2010
18. Schmitt PJ, Jane JA Jr: A lesson in history: the evolution of endoscopic third ventriculostomy. **Neurosurg Focus 33:** 2012
19. Sokal P, Birski M, Rusinek M, Paczkowski D, Zieliński P, Harat A: Endoscopic third ventriculostomy in treatment of hydrocephalus. **Wideochir Inne Tech Malo Inwazyjne 7:**280-285, 2012
20. Warf BC: Hydrocephalus in Uganda: the predominance of infectious origin and primary management with endoscopic third ventriculostomy. **J Neurosurg 102(1 Suppl):**1-15, 2005
21. Warf BC, Mugamba J, Kulkarni AV: Endoscopic third ventriculostomy in the treatment of childhood hydrocephalus in Uganda: report of a scoring system that predicts success. **J Neurosurg Pediatr 5:**143-148, 2010